ALUMINUM

Project Fact Sheet

Semi-Solid Aluminum Alloys

Benefits

- Potential for better control of flow, final porosity and microstructure of cast parts
- Cast products with near-net-shape complex geometries
- Reduced energy consumption due to lower temperature processing of billets
- Increased productivity due to shorter solidification times, reduced shrinkage, and longer die life
- Improved ductility and dimensional repeatability compared to conventional cast products

Application

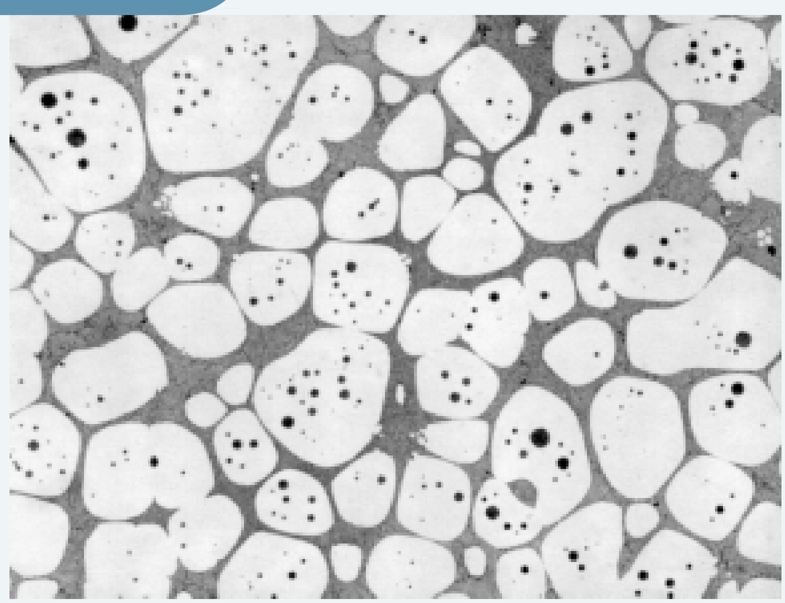
Semi-solid processing is ideally suited for the production of large volume components, such as in the automotive industry. The successful completion of this project will provide the needed knowledge base required to help U.S. aluminum industry in the development and implementation of the semi-solid process.

Semi-solid forming produces high quality die cast parts

Semi-solid material (SSM) processing offers distinct advantages over other near-net-shape manufacturing processes. In this process, cast parts are produced from a slurry kept at a temperature between the solidus and the liquidus isotherms. This process produces complex parts with better quality when compared to parts made by similar processes. It also allows net-shape forming, reducing further machining operations. The process combines the advantages of both liquid metal casting and solid metal forging.

Typically, the process is implemented in two stages. In the first stage, the raw material is prepared so that during solidification of the alloy melt the dendrites that usually form are destroyed by mechanical or electromagnetic stirring. In the second stage, the material is reheated to a temperature in the “mushy” zone and processed into final parts. The semi-solid material exhibits both solid- and liquid-like behaviors. As a “solid”, the material maintains its structural integrity; therefore, during processing it can be handled like a solid. As a “liquid”, the material flows with relative ease and fills die cavities in a progressive fashion. Semi-solid casting offers distinct advantages, such as a more homogeneous microstructure, less porosity, and, thus, excellent mechanical properties.

Semi-Solid Aluminum Alloys



Photograph of special microstructure in semi-solid metal. When heated to the “mushy” zone, the material flows as a fluid, but retains other solid-like behaviors.

Project Description

Goal: Achieve a better understanding of the fundamental issues concerning the constitutive behavior of semi-solid materials and their behavior during processing, so that the applicability of semi-solid forming can be extended to various aluminum alloy systems.

Worcester Polytechnic Institute (WPI) will be using numerical simulation to predict die filling and, ultimately, die design optimization. A Herschel-Bulkley fluid model, modified to account for the two-phase nature and time-dependent rheological behavior of SSM slurries, will be used with specially developed computational codes for semi-solid fluid flow and die filling to produce simulations for the filling of two-dimensional (2-D) and three-dimensional (3-D) cavities under various processing conditions. Issues related to die design and temperature control will also be addressed using numerical simulations.

The Massachusetts Institute of Technology (MIT) work will concentrate on obtaining fundamental rheological data needed for the WPI modeling and simulation activity. MIT will determine effects of semi-solid slurry structure on flow behavior and flow separation at high shear rates representative of actual forming processes. The work at Oak Ridge National Laboratory (ORNL) will concentrate on characterizing the thermophysical properties of semi-solid aluminum alloys and the development of new optimally designed alloys.

Commercialization Plan

A consortium of over 20 industrial partners is participating and cost-sharing this effort. All results of the research are shared with the consortium members.

Additional Project Partners (WPI Semi-Solid Consortium):

Alcoa Incorporated, Alcoa Technical Center, PA
Buhler, Inc., Minneapolis, MN
Chem-Trend, Inc., Howell, MI
CMI International, Inc., Ferndale, MI
Delphi, Saginaw Steering Systems, Saginaw, MI
Ford Motor Company, Dearborn, MI
Ingersoll Rand Company, Phillipsburg, NJ
Madison-Kipp Corporation, Madison, WI
Mercury Marine, Fond Du Lac, WI
North American Die Casting Association, Rosemont, IL
Northwest Aluminum Company, The Dalles, OR
Ormet Corporation, Wheeling, WV
PCC Thixoforming, Inc., Longmont, CO
Prince Machine, Holland, MI
Reynolds Metals Company, Chester, VA
SPX Contech Division, Portage, MI
Teksid Aluminum Foundry, Inc., Dickson, TN

Project Partners

Cast Metals Coalition
Des Plaines, IL

Massachusetts Institute of Technology
Cambridge, MA

Oak Ridge National Laboratory
Oak Ridge, TN

Worcester Polytechnic Institute
Worcester, MA

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